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Re:	Response to the call for technical proposal on regarding IEEE Project 802.16m channel model
Abstract	We propose some MIMO channel models for different frequency range and bandwidth
Purpose	To suggest MIMO channel model to IEEE 802.16m.
Notice	
Release	
Patent Policy and Procedures	

MIMO channel model for advanced system

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1. Introduction

Wireless channel model has always been the subject to active research, due to continual improvement of wireless technologies. MIMO channel model is a crucial factor in communication system. There are many important MIMO channels such as COST273, COST259, ITU, 3GPP SCM, WINNER, and IEEE 802.11n. Some channel models will not be suited for use, because of enhanced capabilities, increased frequency, increased bandwidth, and increased variety of envisioned deployment scenarios, so the proper MIMO channel models should be selected. As described in [1], in order to achieve the performance targets of IMT-Advanced, sufficiently wide frequency channels need to be provided. This document focuses on the channel models working for advanced system （working at 5GHz frequency and 100MHz bandwidth）. One section discusses the channel models working for short-range (indoor) scenarios. The other section discusses the channel models working for wide-area and short-range scenarios (outdoor and indoor).

2. MIMO Channel Model for short-range scenarios

There is a model which works well at both 2GHz to 5GHz frequency bands [3]. Channel taps are separated in delay at minimum 10ns, so bandwidth of the model is 100MHz.The model is used for short-range scenarios.

2.1 Channel parameters setting

In the model, azimuth spread (AS), angle of arrival (AOA), angle of departure (AOD) values are assigned to each tap and cluster that agree with experimentally determined values reported in the literature. The mean AOA is random with a uniform distribution; the mean cluster AS values is in the 20^{o} to 40^{o} range. The cluster rms delay spread (DS) is highly correlated with AS [4], the cluster rms delay spread and AS can be modeled as correlated log-normal random variables. The DS and AS values are determined in [3] .

The cluster structure, excess delay, power, AOA, AOD, AS is shown in [3] Appendix C.

2.2 Channel correlation matrix

Transmitter array and receiver array correlation matrices are combined to MIMO channel correlation matrix by Kronecker product. This approach assumes that transmitter and receiver power azimuth spectra of each channel tap are separable. The detailed description is in [3] section3.

The correlation matrix for each tap is based on the power azimuth(PAS) with AS being the second moment of PAS[5][6].Using the PAS shape, AS, mean AOA, and individual tap powers, correlation matrices of each tap can be determined as described in[6].

2.3 Path loss model

The path loss model consists of the free space loss L_{FS} (slope of 2) up to a breakpoint distance and slope of 3.5 after the breakpoint distance [7]. For each of the models different break-point distance d_{BP} was chosen

$$L(d) = L_{FS}(d) \qquad d <= d_{BP}$$

$$L(d) = L_{FS}(d_{BP}) + 35\ log_{10}(d / d_{BP}) \qquad d > d_{BP}$$

Where d is the transmit-receive separation distance in m. The standard deviations of log-normal (Gaussian in dB) shadow fading are also included. The values were found to be in the 3-14 dB range [8].

New Model	d_{BP} (m)	Slope before d_{BP}	Slope after d_{BP}	Shadow fading std. dev. (dB) before d_{BP} (LOS)	Shadow fading std. dev. (dB) after d_{BP} (NLOS)
A (optional)	5	2	3.5	3	4
B	5	2	3.5	3	4
C	5	2	3.5	3	5
D	10	2	3.5	3	5
E	20	2	3.5	3	6
F	30	2	3.5	3	6

Table1 Path loss model parameters

2.4 Ricean K-factor

K-factor values for LOS conditions are described in[9][10].The LOS K-factor is applicable only to the first tap while all the other taps K-factor remain at dB. LOS conditions are assumed only up to the breakpoint distance in [3] section4.1 tableII.

The IEEE802.11n model uses mostly more than 10 taps (14 to 18) with minimum tap spacing of 10ns.From these figures it can be assumed that it would support the 100MHz bandwidth, so the model will work well for 5GHz and wide band in short range.

3 MIMO Channel Model for wide-area and short-range scenarios

WINNER model covers the frequency ranges from 2GHz to 5GHz and the bandwidth of 100MHz.The models are based on the existing literature and the parameters extracted from eleven measurement campaigns performed by the WINNER Work Package 5(WP5).The selection of the model parameters is based both on the measurements and literature. The model can be used for short-range scenarios and wide-area scenarios.

3.1 Channel parameters setting

The channel model parameters were defined for mainly six propagation scenarios, namely indoor small office(A1),urban micro-cell(B1),indoor hotspot(B3),suburban macro-cell(C1),urban macro-cell(C2),rural macro-cell(D1).The analyzed parameters include shadow fading characteristics, power delay profiles, delay spreads, angle-spreads, correlation characteristics, AOA, AOD. Many parameters are measured or gotten at 5GHz frequency.

As an example of scenario rural macro-cell (D1), the distribution of the RMS-delay spread was investigated. The 10, 50, 90% values of RMS-delay spread are given for 5.25GHz in 100MHz bandwidth in LOS and NLOS propagation conditions.

Rms delay spread (ns)		LOS	NLOS
Percentile	10%	2.5	4.3
	50%	15.4	37.1
	90%	84.4	89.5
	mean	36.8	42.1

Table2 percentiles of the RMS-delay spread in a rural environment

Measured angle-spread cumulative distribution function at MS and BS at 5.25GHz are shown as

Rural Tyrnävä		LOS	NLOS
BS, σ_ϕ	10%	10.2	5.6
	50%	21.9	18.0
	90%	36.2	34.3
	mean	21.7	19.5
MS, σ_φ	10%	8.3	6.0
	50%	20.3	22.3
	90%	37.5	36.4
	mean	22.4	21.9

Table3 percentiles of the RMS angle spread

The percentiles of the path delays are shown below

Path delay (ns)		LOS	NLOS
Percentile	10%	0	0
	50%	100	80
	90%	403	294
	mean	165	124

Table4 the percentiles for the cumulative distribution function of the Path delays for LOS and NLOS at 5.25GHZ

These parameters are described in [11] detailedly.

3.2 Ricean-K factor and LOS probability

The K-factor for LOS scenarios is shown in table5

Scenarios	A1	B1	B2	C1	D1
K[dB]	8.7+0.05*d	3+0.0142*d	6-0.26*d	17.1-0.021*d	3.7+0.019*d

Table5 k-factor for LOS scenarios

The probability for LOS is shown in table6

Scenarios	A1	B1

probability	$P \begin{cases} 1, d \quad 2.5m \\ 1 \quad 0.9(1 \quad (1.24 \quad 0.61\log10(d))^{3})^{1/3}, d \end{cases}$	$P \begin{cases} 1, d \quad 15m \\ 1 \quad (1 \quad (1.56 \quad 0.48\log10(d))^{3})^{1/3}, d \quad 15m \end{cases}$
Scenarios	B3	C1
probability	For the big factory halls, airport and train stations: $P \begin{cases} 1, d \quad 10m \\ \exp(\quad (d \quad 10)/45) \end{cases}$. For big lecture hall or conference hall: $P \begin{cases} 1, d \quad 5m \\ 1 \quad \frac{d \quad 5}{150}, 5m \quad d \quad 40m \end{cases}$	$P \quad \exp(\quad \frac{d[m]}{500m})$
Scenarios	C2	D1
probability	0	$P \quad \exp(\quad \frac{d[m]}{1000m})$

Table6 probability for LOS

3.3 Path loss model

Path loss models at 5GHz have been developed based on measurement results or from literature.

Scenario		path loss [dB]	shadow fading standard dev.	applicability range
A1	LOS	18.7 $\log_{10}(d[\text{m}])$ + 46.8	σ = 3.1 dB	3 m < d < 100 m
	NLOS	36.8 $\log_{10}(d[\text{m}])$ + 38.8	σ = 3.5 dB	3 m < d < 100 m
B1	LOS	22.7 $\log_{10}(d[\text{m}])$+41.0	σ = 2.3dB	10 m < d < 650 m
	NLOS	0.096 $d_1[\text{m}]$ + 65 + (28 – 0.024$d_1[\text{m}]$) $\log_{10}(d_2[\text{m}])$	σ = 3.1dB	10 m < d_1 < 550 m w/2 < d_2 < 450 m *)
B3	LOS	13.4 $\log_{10}(d[\text{m}])$ + 36.9	s = 1.4 dB	5 m < d < 29 m
	NLOS	3.2 $\log_{10}(d[\text{m}])$ + 55.5	s = 2.1 dB	5 m < d < 29 m
C1	LOS	23.8 $\log_{10}(d)$ + 41.6 40.0 $\log_{10}(d/d_{BP})$ + 41.6 + 23.8 $\log_{10}(d_{BP})$ ****) +)	s = 4.0 dB s = 6.0 dB,	30 m < d < d_{BP} d_{BP} < d < 5 km
	NLOS	40.2 $\log_{10}(d[\text{m}])$ + 27.7 **)	σ = 8 dB	50 m < d < 5 km
C2	NLOS	35.0 $\log_{10}(d[\text{m}])$ +38.4 ***)	σ = 8 dB	50 m < d < 5 km
D1	LOS	21.5 $\log_{10}(d[\text{m}])$ + 44.6 40.0 $\log_{10}(d/d_{BP})$ + 44.6 + 21.5 $\log_{10}(d_{BP})$ ****) +)	σ = 3.5dB σ = 6.0dB	30 m < d < d_{BP} d_{BP} < d < 10 km
	NLOS	25.1 $\log_{10}(d[\text{m}])$ + 55.8	σ = 8.0dB	30 m < d < 10 km

*) w is LOS street width, d_1 is distance along main street, d_2 is distance along perpendicular street.

**) Validity beyond 1 km not confirmed by measurement data.

***) Validity beyond 2 kms not confirmed by measurement data.

****) d_{BP} is the break-point distance: $d_{BP} = 4\ h_{BS}\ h_{MS}$ / ?, where h_{BS} is antenna height at BS, h_{MS} is antenna height at MS, and ? is the wavelength. Validity beyond d_{BP} not confirmed by measurement data.

+) BS antenna heights in the measurements: C1 LOS: 11.7 m, D1: 19 – 25 m.

Table7 path loss models

3.4 Clustered delay line model

The model is some different from the conventional tapped delay line models in a sense that fading within each tap is generated by a sum of sinusoids. Clustered delay line model is composed of a number of separate delayed clusters. Each cluster has a number of multipath components that have the same known delay values but differ in known angle of departure and known angle of arrival. The average power, mean AOA, mean AOD of clusters, angle-spread at BS and angle-spread at MS of each cluster in the clustered delay line are extracted or estimated from measurement results at 5GHz and chip frequency of 100MHz.

The clustered delay line models of different scenarios are shown in [11] Section3.2.

WINNER MIMO Channel Model is realistic enough and simple. It may be the most proper one to be used to 5GHz frequency and 100MHz bandwidth for different scenarios.

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